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A COMPARISON OF BOTTOM LONGLINE AND DEEP-SEA HANDLINE FOR SAMPLING BOTTOM FISHES IN THE HAWAIIAN ARCHIPELAGO

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INTRODUCTION

The Hawaiian Archipelago, an elongated submarine ridge extending approximately 3,150 km from southeast to northwest, is composed of eight major islands and 12 islets, atolls, and near-atolls (Fig. 1). Population centers in the State of Hawaii are found in the lower main islands, which extend from Hawaii to Niihau, and the largely uninhabited Northwestern Hawaiian Islands (NWHI) continue from Nihoa to Kure Atoll.

The marine fauna of Hawaii is an outlier of the extensive marine zoogeographic province centered in the East Indies; however, the bottom fish species complex is not as diverse as in the western Pacific (Uchida et al.[1]). In Hawaii the shelf zone is narrow, poorly developed, and fish species are found in small multispecies aggregates, unlike the continental shelves that characterize most of the world's great fishing areas, where single fish species are often found in large populations.

The commercial deep-sea bottom fish fishery for snappers (Lujanidae), jacks (Carangidae), and groupers (Serranidae) in this narrow shelf zone, is primarily a handline fishery that historically was carried out in the lower main islands, with only a few long-range vessels venturing into the NWHI (Ralston[2]). Because of increasing interest in the marine resources of the NWHI, in 1975 the National Marine Fisheries Service (NMFS) Southwest Fisheries Center Honolulu Laboratory initiated a 5-yr tripartite (State of Hawaii, National Marine Fisheries Service, NOAA, and U.S. Fish and Wildlife Service) cooperative agreement to survey and assess these resources (Uchida and Uchiyama 1986). As part of this program the NMFS assumed the responsibility for research on offshore banks and seamount resources, including the commercially important bottom fishes. The characteristic rough bottom habitat of these fishes, along or near steep drop-offs, prevented the effective use of many sampling gears, including trawls and fish traps. At the time, the deep-sea handline gear employed by Hawaiian commercial bottom fish fishermen proved to be the most effective method of catching bottom fish and, consequently, this gear was used as the primary sampling method for bottom fish during the NWHI study (Moffitt 1980).

Deep-sea handline fishing, however, has limitations. Fishing effort is restricted to several (two-five) lines because of limited deck space. Also, drift of the vessel is susceptible to sea, wind, and current conditions, making it difficult to maintain precise depth zones while fishing. As a result it is difficult to determine the depths at which fish are

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[1]Uchida, R. N., B. M. Ito, and J. H. Uchiyama. 1979. Survey of bottom fish resources in the Northwestern Hawaiian Islands. National Marine Fisheries Service, NOAA, Honolulu, Hawaii. Southwest Fisheries Center Administrative Report H-79-20, 19 p.

[2]Ralston, S. 1979. A description of the bottom fish fisheries of Hawaii, American Samoa, Guam, and the Northern Marianas. A report submitted to the Western Pacific Regional Fishery Management Council, 102 p.

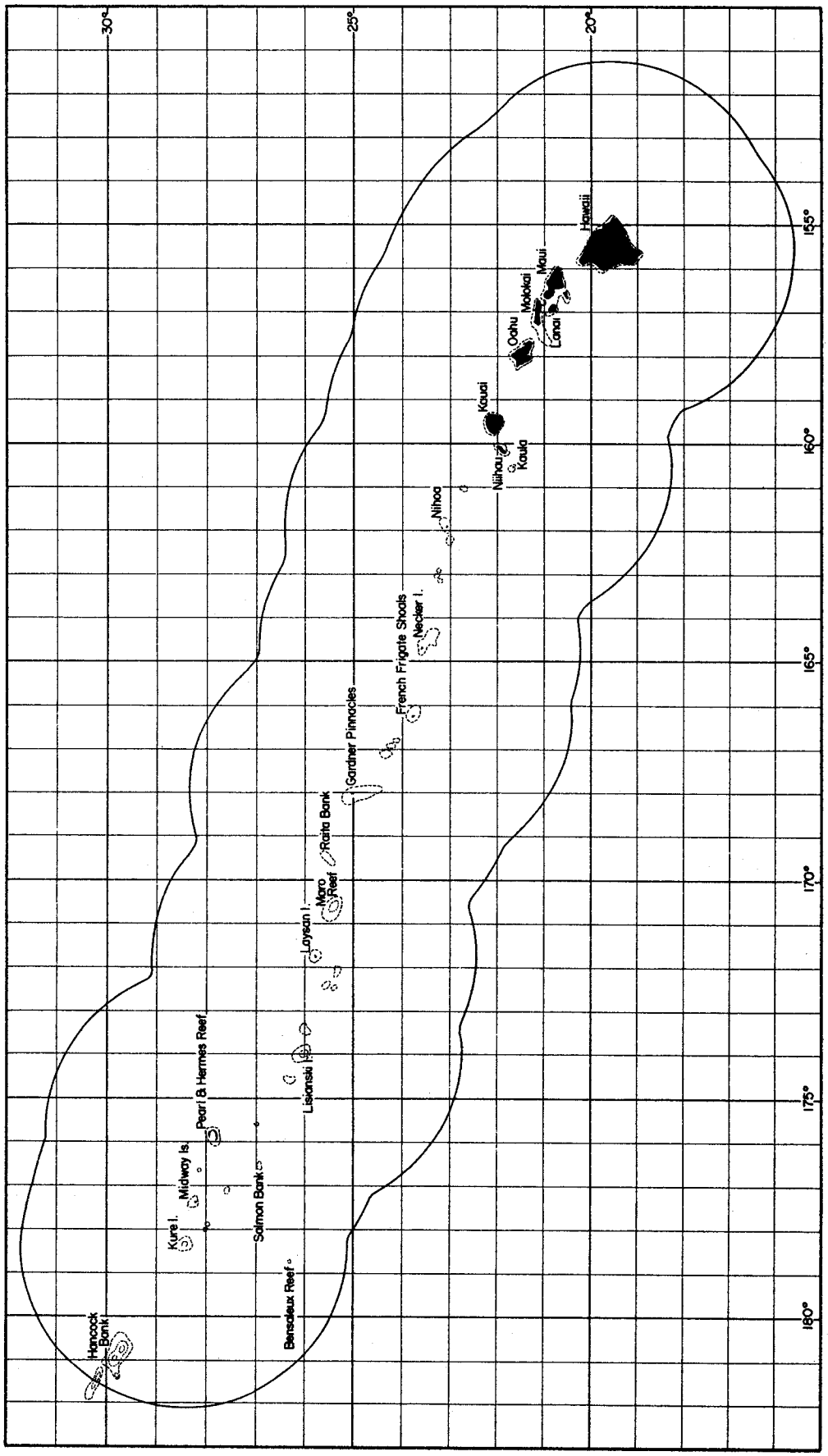

Figure 1.--The Hawaiian Archipelago.

caught. The differing abilities of individual fishermen can also influence the catch rate of each line.

All these factors diminish the effectiveness of deep-sea handline fishing as a method for assessing fish stocks. Bottom longline, however, appears to be a logical alternative to overcome many of the limitations of handline fishing. This paper discusses the results of gear trials that were completed to evaluate the bottom longline as an alternative method of fishing for sampling bottom fishes.

Bottom Longline Development

The evolution and development of bottom longlines is very poorly documented. The Japanese have used bottom longlines beginning at least in the early 1900's and have developed a wide variety of designs for their coastal and far seas fisheries. In the United States the commercial use of bottom longlines is a post-World War II development; the bottom longline is used in the Pacific halibut, sablefish, and spiny dogfish fisheries along the west coast of the United States and the snapper and tilefish fisheries off the Florida coast (High 1980; Putnam 1984). A number of modern automated bottom longline systems capable of fishing thousands of hooks per day are now commercially available. The majority of these, however, are suitable for fishing only on relatively flat bottom and are easily fouled when fished over rough areas.

MATERIALS AND METHODS

All deep-sea bottom handline fishing operations referred to in this paper were conducted with four hydraulically operated handline gurdies on the NOAA ship Townsend Cromwell. Fishing was done while the ship drifted on or near the edge of banks at depths of 46-293 m. Deep-sea handline gear consisted of a braided dacron mainline with a breaking strength of 120.2 kg (265-lb test), a 90.7-kg (200-lb) test hard-nylon monofilament leader with four 50-cm (19-1/2 in.) long 45.4-kg (100-lb) test hard-nylon monofilament branch hook lines, and a 2.7-kg (6-lb) lead weight. Recurved No. 26 Izuo[3] circle hooks were used exclusively on the handlines during the cruise.

Each handline was usually retrieved when a fish was hooked, regardless of whether or not the remaining three hooks were still baited. When biting was slow, lines were retrieved frequently to check for unbaited hooks. Strips of frozen squid were used as bait during all handline stations.

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[3]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

Bottom Longline Design A

The rough bottom habitat occupied by bottom fish in Hawaii precluded the use of conventional bottom longlines in which the main or ground line lies on the sea floor while fishing. Jarvis (1935) and Whiteleather and Brown (1945) reported large gear losses when such bottom longlines were used on rough bottom in the Gulf of Mexico and Caribbean.

To reduce gear loss due to entanglement on rough bottom, a bottom longline design in which the mainline could be kept off the bottom and yet fish on or near the bottom is necessary. The first two bottom longline designs, A and B, that were field tested were adapted from Japanese deep-sea vertical longlines and cod longlines. The float and mainline of both bottom longlines consisted of 4.7-mm (3/16 in.) diameter tarred kuralon rope. In design A, 1-m (3-ft 1 in.) long, single-hook gangions along with small plastic floats were spaced 3 m (9 ft 10 in.) apart on the mainline (Fig. 2). At 10-hook intervals, 2.3-kg (5-lb) lead weights on 5-m (16-ft 5 in.) lengths of 3.1-mm (1/8 in.) diameter kuralon rope and 112.5-mm (4-1/2 in.) diameter glass floats were attached to the mainline. Each set contained 100 hooks and the terminal ends of the mainline were anchored with 11.3-kg (25-lb) weights and marked with floats.

Bottom Longline Design B

Bottom longline design B, was similar in construction to design A, except that each dropper was spaced 20 m (65 ft 7 in.) apart and contained five hooks (Fig. 3). Each dropper consisted of a 3-m long section of 3.1-mm diameter kuralon rope joined to a 5-m long 68-kg (150-lb) test hard-nylon monofilament branch line. At 1-m intervals, three-way swivels were attached to the branch line to which single 30.8-cm (12-in.) long hard-nylon monofilament hook lines were attached. Along with each dropper, a 112.5-mm diameter glass ball was attached to the mainline. Each set was fished with 100 hooks.

Deploying and Retrieving Bottom Longline Designs A and B

Both bottom longline systems were set from the stern of the vessel at a speed of about 2 kn. A 4-m (13-ft 4-1/2 in.) long, 31.3-mm (1-1/4 in.) diameter galvanized pipe, fitted with twenty 12.5-mm (1/2-in.) diameter 18.6-cm (7-1/4 in.) long steel rods was mounted on a horizontal plane, 1 m above the deck on the edge of the Cromwell's stern. These rods, spaced 19.2 cm (7-1/2 in.) apart and facing over the edge of the stern, were used to hold five baited hooks each during the setting operation. With both gear types, the mainline was first coiled and laid out under the setting bar prior to setting. The droppers and floats were then attached to the mainline and the baited hooks hung from the rods on the setting bar. In setting bottom longline A, one of the terminal floats was deployed first, and as the hooks were pulled off the rods, the lead weight between each set of 10 hooks was thrown over in sequence. In setting bottom longline B, the lead weight for each dropper was thrown over in sequence as the mainline was set.

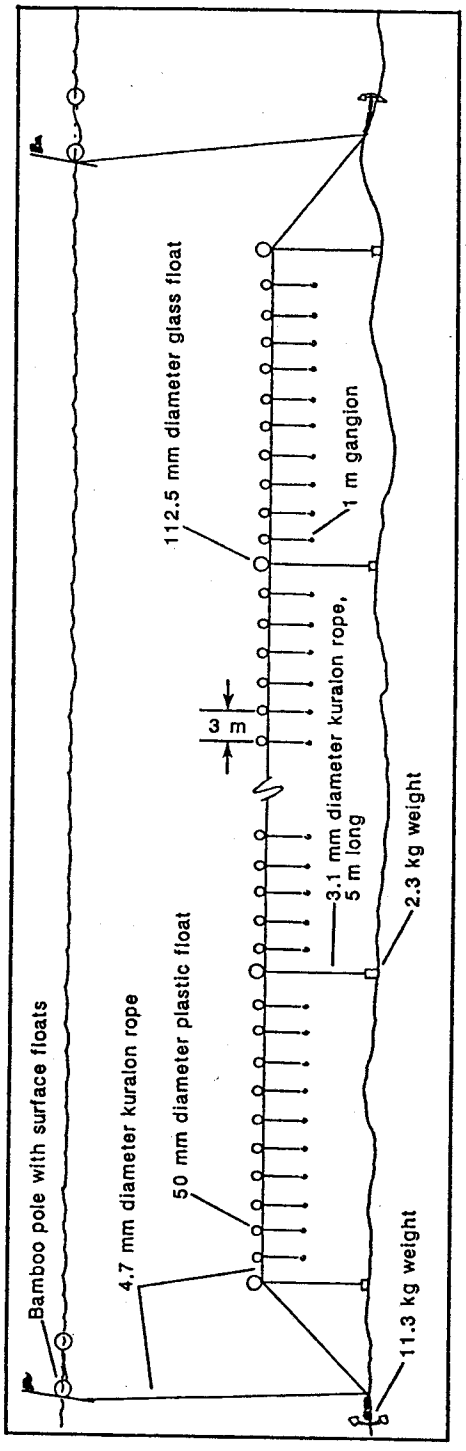

Figure 2.--Bottom longline design A.

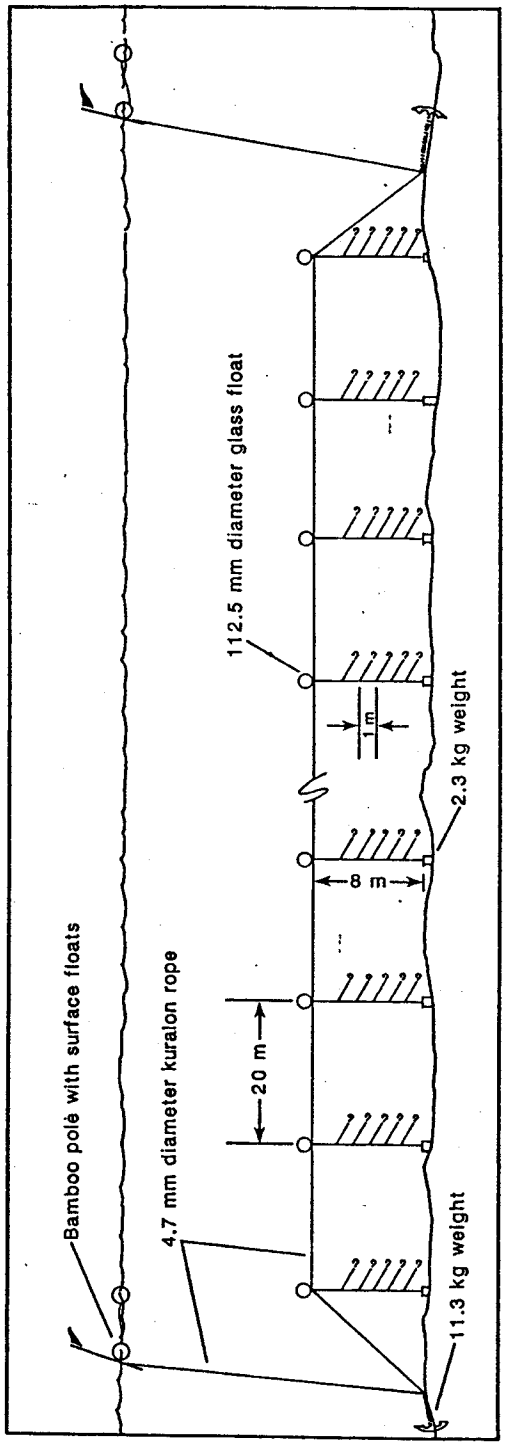

Figure 3.--Bottom longline design B.

The procedure for retrieving bottom longlines A and B was a reversal of the setting procedure. As the mainline was retrieved with a hydraulic pot hauler and coiled into plastic barrels, the droppers, floats, and weights were removed and stored in plastic buckets.

Modified Kali Bottom Longline

The third bottom longline system field tested in November 1984 was a modified version of the Kali bottom longline system, developed in the Caribbean by Kali Seafood Inc.[4] The gear is similar in design to bottom longline B except that polyvinyl chloride (PVC) pipes were used as droppers. The mainline consisted of 9.4-mm (3/8 in.) diameter, twisted, three-strand, floating polypropylene rope with PVC droppers attached at 18.3-m (60-ft) intervals and 15.9-kg (35-lb) anchors and marker floats at the terminal ends. Rope beckets on the mainline in the original Kali bottom longline design were replaced with wire bridles constructed of 15.4-cm (6-in.) long sections of 3.1 mm diameter 7 x 19 stainless wire rope, crimped with copper sleeves between two No. 2 bulldog swivels (Fig. 4). On tuna longline gear these wire bridles were very effective in eliminating the tendency for droppers to twist around the mainline (Mann 1955). The droppers are constructed of 2.9-m (9-1/2 ft) long, 12.5-mm diameter, schedule 80 PVC pipes (Fig. 5). Each dropper was fished with five hooks spaced 46.2 cm (18 in.) apart compared to 10 hooks on the original Kali longline design. The branch leaders for the hook lines are attached to the PVC poles through five 4-mm (five 32-in.) diameter holes drilled in each pole through which 30.8-cm long sections of 90.7-kg test hard-nylon monofilament are threaded and snugly crimped to the pole with copper sleeves. The 90.7-kg test monofilament branch leader, is terminated with a No. 5 barrel swivel. A 11.5-cm (4-1/2 in.) long hook leader of either 36.3-kg (80-lb) test or 45.4-kg test monofilament with a No. 24 or 26 Izuo circle hook is attached to the barrel swivel by a loop on the end of each leader. The PVC droppers are weighted with 43.6-cm (17-in.) long, 0.5-kg (1-lb) sections of 9.4-mm diameter reinforcing bars inserted into the bottom ends of the PVC pipes. A 92.3-cm long, 6.3-mm (1/4 in.) diameter polypropylene rope with a 100-mm (4-in.) diameter plastic float is spliced to the top end of each PVC pipe through a 6.3-mm diameter hole drilled 2.6 cm (1 in.) from the end of each pole and a No. 3 tuna AK snap is spliced to the terminal end of the rope. The 3.2-m (10-ft 6 in.) long PVC droppers are stored in 3.1-m (10-ft) long, 50-mm (2-in.) diameter schedule 10 PVC pipes, which are arranged in horizontal racks of 10 pipes each (Fig. 6). A rack stand constructed of 75-mm (3-in.) diameter schedule 40 PVC pipes is used to hold 6 of these storage racks for a total of 60 droppers. Before setting, the droppers are removed from the storage tubes, baited, and reinserted into the storage tubes.

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[4]Catch '82. Caribbean longlining technique. An article supplied by Nicholas Zinkowski, President of Kali Seafood Inc., Culeora, Puerto Rico, p. 9-10.

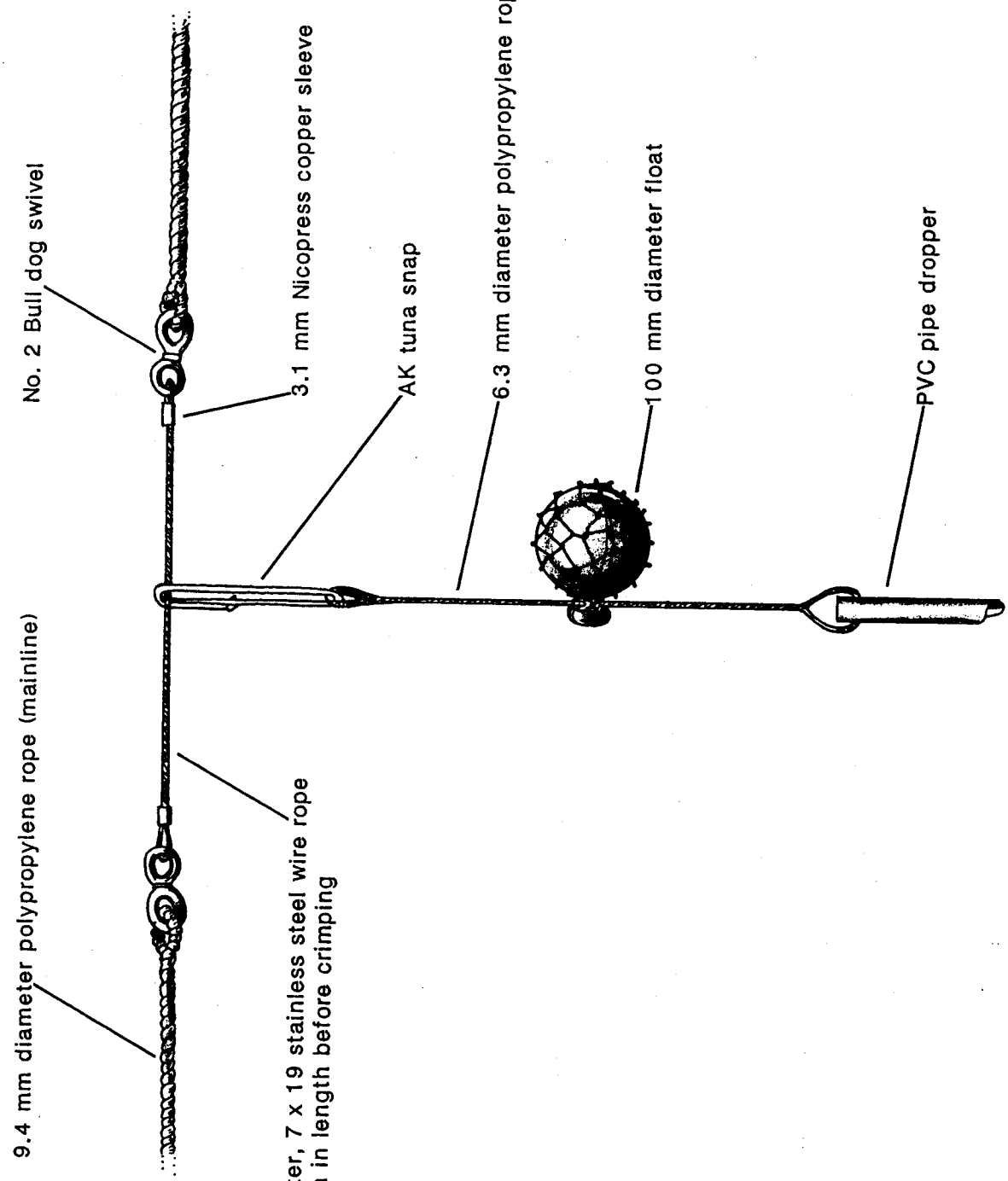

Figure 4.--Wire bridle dropper attachment (adapted from Mann 1955).

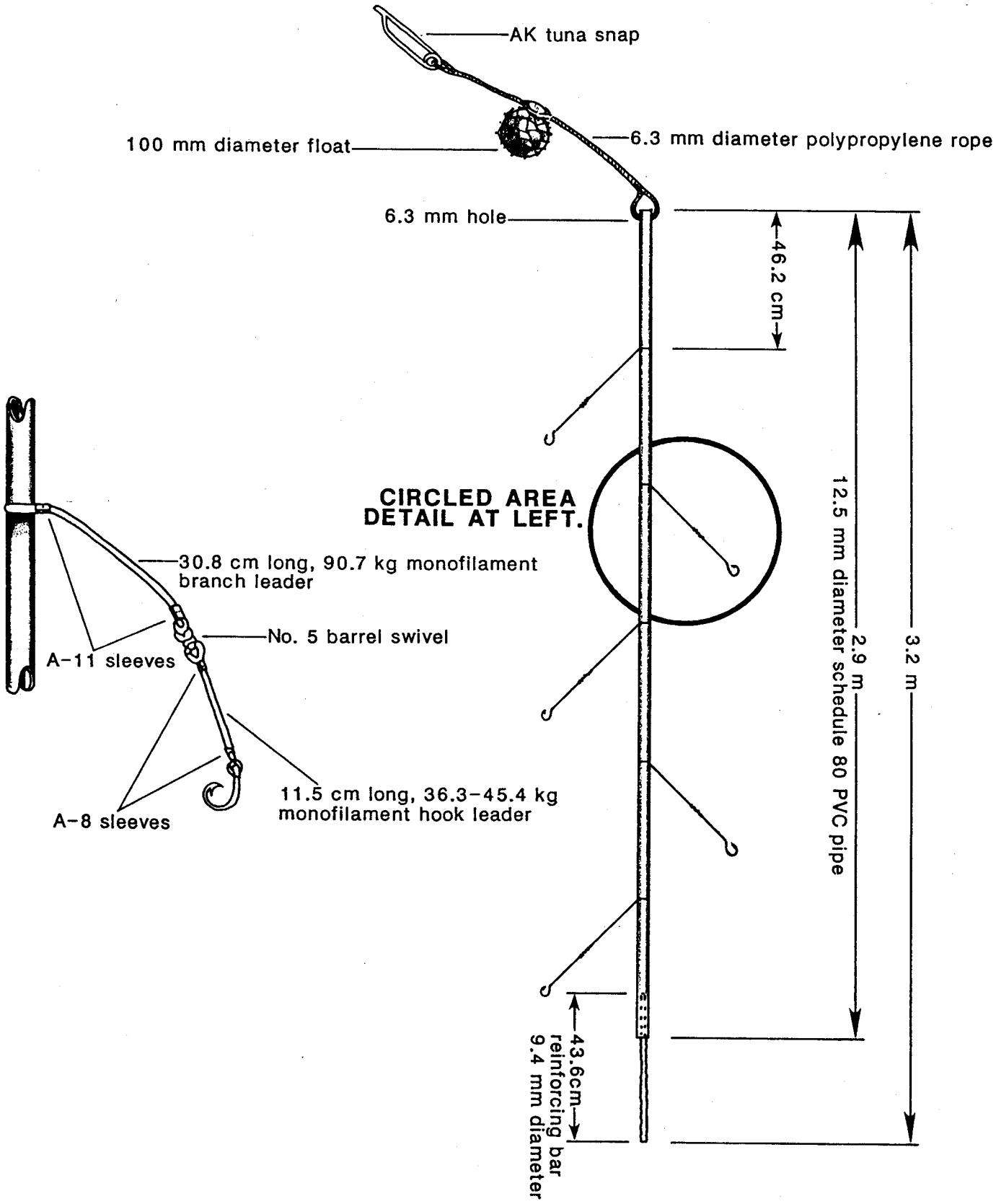

Figure 5.--Bottom longline polyvinyl chloride dropper.

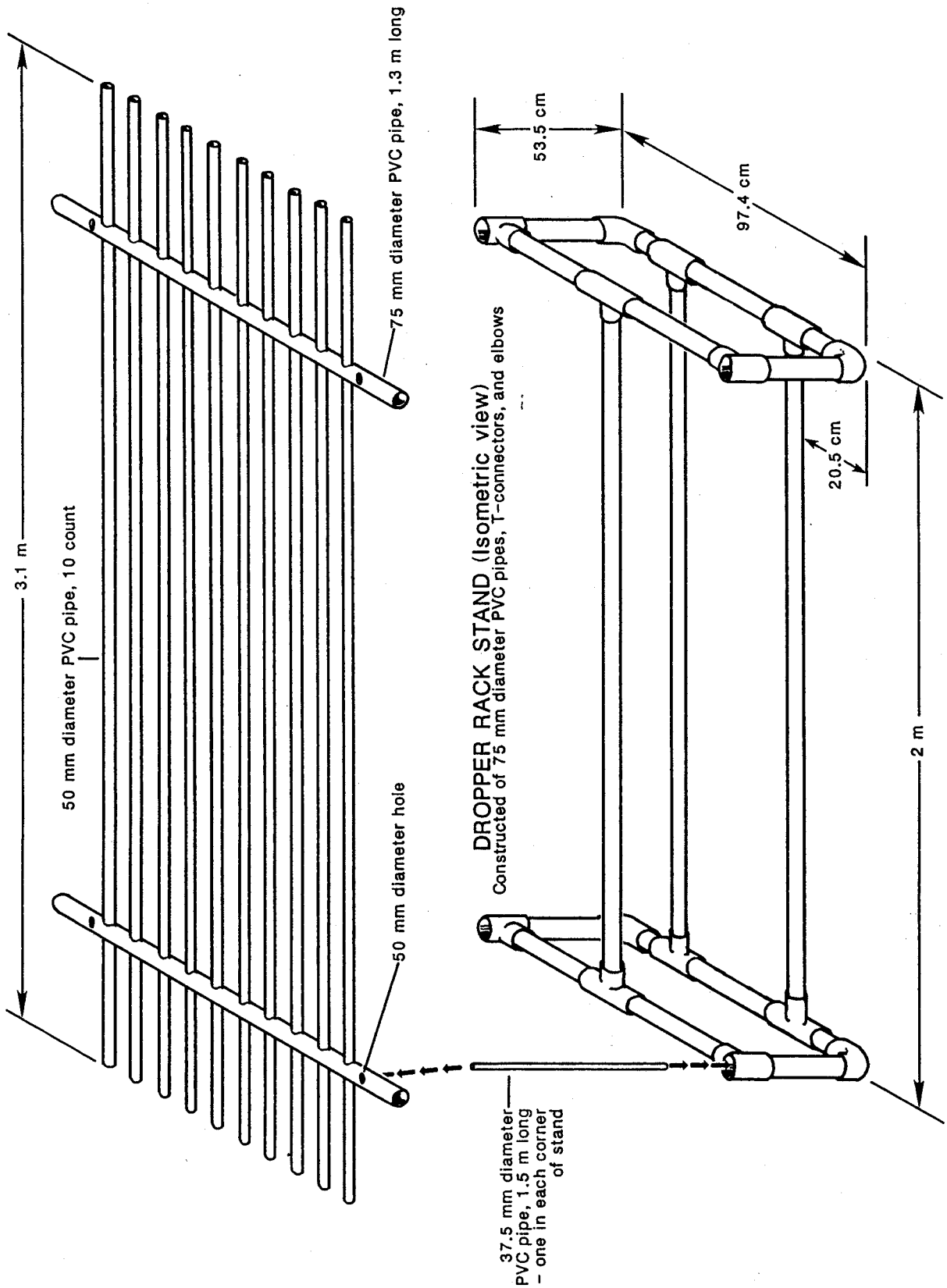

Figure 6.--Bottom longline dropper rack and dropper stand.

Deploying and Retrieving the Modified Kali Bottom Longline

The gear is set while the vessel is underway at a speed of 2 kn. The terminal floats, float line, and anchor are first deployed and as the mainline is pulled out, the droppers are individually removed from the storage tubes and snapped on the wire bridles on the mainline. Sets of 30 droppers (150 hooks) and 60 droppers (300 hooks) were fished during the cruise.

Retrieval of the gear is a reversal of the setting procedure. As the mainline is retrieved and coiled into plastic barrels, the droppers are unclipped from the mainline and immediately reinserted into the storage tubes after the fish are removed. As in handline fishing, strips of frozen squid were used exclusively as bait on all bottom longline stations.

All catches were processed at sea during or immediately following each station. Species, sex, weight, and fork or total length measurements of all commercially important species caught were recorded. All references to catch by species refer to the catch of the eight most important commercial species: ehu, Etelis carbunculus; onaga, E. coruscans; opakapaka, Pristipomoides filamentosus; kalekale, P. sieboldii; gindai, P. zonatus; butaguchi, Pseudocaranx dentex; kahala, Seriola dumerili; and hapuupuu, Epinephelus quernus.

The deep-sea bottom handline and Kali bottom longline were selected to compare handline fishing and bottom longline fishing. During handline fishing the basic gear unit was four handlines (total of 16 hooks fishing simultaneously). Handline fishing effort was the elapsed time from the first handline entering the water at the start of a station to retrieval of the last handline at the end of the station, regardless of the number of drifts or line retrievals made during the station. Similarly, bottom longline fishing, with either 30 droppers (total of 150 hooks) or 60 droppers (total of 300 hooks), was used to define the gear unit of bottom longline. Bottom longline fishing effort was the elapsed time between setting the first float and retrieval of the last float. In data analysis, the number of fish and the total weight were used to calculate the catch per unit effort (CPUE). The effectiveness of the two gear types was determined by comparing CPUE statistics.

AREA OF OPERATION

Bottom longline designs A and B were field tested in depths of 110-220 m off the coast of Kawaihae on the Island of Hawaii in December 1979, and the Kali system was field tested at Necker Island and Maro Reef during October 1984 in depths of 55-274 m during cruises of the Townsend Cromwell (TC-79-05 and TC-84-05, respectively). All deep-sea bottom handline fishing operations during TC-84-05 were conducted at Maro Reef in depths of 121-152 m. Deep-sea bottom handline fishing was conducted at Necker Island and Maro Reef during the NWHI survey on Townsend Cromwell cruises 77-03 through 81-04.

RESULTS

Handline Fishing Results

At Maro Reef, five different bottom fish schools in depths of 121-152 m were fished in five handline stations in conjunction with bottom longline operations. The handline CPUE was 21.53 fish/h and 121.87 kg/h. The highest catch rate on a single station was 41.67 fish/h and 169.87 kg/h. Opakapaka, hapuupuu, and butaguchi accounted for more than 87% of the catch.

Bottom Longline Fishing Results

A total of 5,355 hooks were fished in 25 stations at Necker Island and Maro Reef; fishing times ranged from 35 to 120 min. Of these, 1,335 hooks were fished in nine 30-dropper stations at Necker Island, and 2,530 hooks were fished in five 30-dropper stations and six 60-dropper stations at Maro Reef. In addition, five 60-dropper stations (1,490 hooks) were fished on five different fish schools in conjunction with five bottom handline fishing stations at Maro Reef.

Performance of Bottom Longline Designs A and B

After a total of only six sets, two with longline A and four with longline B, in depths of 110-220 m, it was apparent that these two designs were not suitable for efficiently sampling bottom fish and further use of these two designs was abandoned. With both designs, storage of the droppers and preparation of the gear for deployment were time consuming and complicated by frequent tangling of the droppers. During retrieval of gear, tangling and twisting of the droppers with the mainline was a major problem. Over 20 and 26%, respectively, of the droppers were badly tangled and wrapped around the mainline. Many of the tangles appeared to have occurred during retrieval of the gear when the mainline and droppers are nearly vertical. Additionally, extensive ship maneuvering was frequently necessary to free lead weights that were caught on the bottom. Moreover, system B suffered an 18% bent and lost hook rate due to hooks snagging on the rough bottom. Because of the numerous tangles and exposed hooks on deck, safety was also a real concern, especially for personnel inexperienced in handling hooks.

Performance of the Modified Kali Bottom Longline

The general performance of the Kali bottom longline was excellent and no serious problems were encountered in preparing, setting, and retrieving the gear. Baiting and preparing a 30-dropper set required approximately 0.5 man-hours, whereas a 60-dropper set took about twice as long. A deck crew of four easily deployed 30- and 60-dropper sets in 12 and 20 min, respectively. Retrieval required approximately 30 min for a 30-dropper set and 45 min for a 60-dropper set, depending on the number of fish caught and

prevailing sea conditions. Because the droppers were removed from their storage tubes one at a time during setting operations and were immediately reinserted into the storage tubes when retrieved, the likelihood of deck personnel being accidentally injured by exposed hooks was minimal.

Early in the cruise some difficulty was experienced with the gear missing targeted schools due to current drift. As the cruise progressed, however, the incidence of misplaced gear decreased as the vessel operators became more proficient in allowing for current drift when deploying the bottom longline.

Gear loss due to snags on the bottom was minimal. Of the 1,071 droppers set during the cruise, only 5, or <0.5% were lost as a result of snags on the bottom. The gear held the bottom well even when set parallel along slopes as steep as 45°. During retrieval the ship follows the path of the gear so the mainline hangs nearly vertical while being recovered, thus minimizing bottom fouling. At this time the depths fished can be easily verified with a Furuno depth recorder. Also the floats on the bottom longline can often be detected by retracing the path of the gear with a Furuno depth recorder before retrieval. Severe problems of shark damage to gear were anticipated but did not materialize. Except for the loss of 34 droppers during a 60-dropper set at Maro Reef, when a large shark severed the mainline at the surface while attacking a hooked hapuupuu, very few problems were encountered with sharks. Only an occasional fish was shark damaged.

Modified Kali Bottom Longline Catches

The CPUE of the 30-dropper bottom longline was 6.33 fish/h and 15.03 kg/h at Necker Island and 8.15 fish/h and 38.28 kg/h at Maro Reef (Table 1). The best CPUE on a single set was 11.84 fish/h and 23.55 kg/h fished at Necker Island and 15.52 fish/h and 103.97 kg/h fished at Maro Reef. Seven of eight commercially important species that inhabit the depths fished were represented in the catches, and opakapaka and hapuupuu together accounted for over 50% of the landings, followed by butaguchi (16.4%) and kahala (14.6%).

The 60-dropper bottom longline sets deployed at Maro Reef had a CPUE of 14.31 fish/h and 77.26 kg/h (Table 1); opakapaka accounted for over 57% of the catch, followed by butaguchi (23.3%) and hapuupuu (15.2%). Kalekale, gindai, ehu, and onaga, which prefer deeper depths, were not represented in the landings. The best CPUE on a single set was 36.44 fish/h and 186.44 kg/h.

Thirty-Dropper Versus Sixty-Dropper Bottom Longline

As can be seen from Table 1, the 60-dropper bottom longline had a higher CPUE than the 30-dropper bottom longline. At Maro Reef the 30-dropper bottom longline was outfished by more than 1.8 times in fish per fishing hour and more than 2 times in kilograms per fishing hour by the 60-

Table 1.--Summary of bottom longline fishing during Townsend Cromwell cruise 84-06 at Necker Island and Maro Reef (BLL = bottom longline).

Area	Gear	Depth (m)	Effort in fishing hours	Fish per fishing hour	Kilograms per fishing hours	Total fish	Total (kg)
Necker	30-dropper BLL	55-274	13.59	6.33	15.03	86	204.3
Maro	30-dropper BLL	110-210	6.75	8.15	38.28	55	258.4
Maro	60-dropper BLL	119-156	14.31	14.68	77.26	210	1,105.6

dropper bottom longline. The 30-dropper sets at Necker Island were outfished by more than 2.3 times in fish per fishing hour and more than 5 times in kilograms per fishing hour by 60-dropper sets made at Maro Reef.

Bottom Longline Versus Deep-Sea Handline

The CPUE's of bottom fish at Necker Island and Maro Reef when using the 30-dropper bottom longline are very similar to results obtained from these two areas by bottom handline fishing during the NWHI survey (Table 2). This comparison, however, must be viewed with caution. Handline fishing during the NWHI survey was conducted over a wider range of depths than bottom longline fishing and, unlike the bottom longline sets which targeted on fish schools, many of the handline stations did not. In addition, it is probable that increased commercial fishing pressure at these sites since 1977 has had an effect on the fish populations.

To compare bottom longline fishing with deep-sea bottom handling fishing (4 lines), the 60-dropper bottom longline was selected because it was long enough to cover the area occupied by the largest fish schools encountered. Bottom handline and bottom longline CPUE's were virtually identical: 21.53 fish/h and 121.87 kg/h for handline fishing versus 22.37 fish/h and 121.17 kg/h for bottom longline fishing. The mean size of fish caught was 8.12 kg for handline fishing and 7.29 kg for bottom longline fishing, a difference of <1 kg. The available data were insufficient to perform regression analysis of catches between the two gear types as well as a species by species analysis.

The time spent in locating suitable bottom fish schools ranged from a few minutes to over 90 min and was not gear dependent. Although preparing the 60-dropper bottom longline for deployment took about 0.5 man-hours more than preparing the deep-sea bottom handline gear for a station, all preparation was easily completed while the vessel searched for fish schools.

Although data were insufficient to perform a regression of catch rate with length of set for the bottom longline, the effectiveness of the gear tended to decrease with the length of the set. The available data suggest an optimum set length of 35 to 75 min.

Hook Loss Rate

During the first half of the cruise at Necker Island, the Kali bottom longline, fished with 36-kg breaking strength hook leaders, suffered a hook loss rate of 0.63 hooks lost/fish caught (Table 3). Increasing the hook leader size to 45.4 kg breaking strength during the second half of the cruise at Maro Reef reduced the losses to 0.22 hooks lost per fish caught. The average weight of fish caught at Maro Reef was twice that of fish caught at Necker Island (5.25 kg versus 2.60 kg). The difference in the average size of fish caught by the two different leader sizes was not the result of increased hook leader strength, however, but was due to larger fish at Maro Reef. Six bottom fish schools at Maro Reef fished with deep-sea handlines

Table 2.--Summary of deep-sea handline fishing during Townsend Cromwell Northwestern Hawaiian Islands cruises (77-03 through 81-04) at Necker Island and Maro Reef.

Area	Gear	Depth (m)	Effort in fishing hour	Fish per fishing hour	Kilograms per fishing hour	Total fish	Total (kg)
Necker	Handline	46-293	84.53	6.52	17.18	551	1,452.2
Maro	Handline	66-274	25.40	8.07	35.23	205	894.9

Table 3.--Hook loss rates between two hook leader sizes fished with Kali bottom longline during Townsend Cromwell cruise 84-06.

Hook leader size (kg)	Number of hooks lost	Effort in 100-hook hours	Total fish	Total (kg)	Average fish weight (kg)	Hooks lost per fish caught	Hooks lost per kilogram caught
36.3	65	22.41	103	267.5	2.60	0.63	0.24
45.4	55	49.48	248	1,300.8	5.25	0.22	0.04

and bottom longlines (with 45.4-kg breaking strength hook leaders) resulted in landing fish virtually identical in size (Table 4). Hook losses on the bottom longline, however, were four times higher than those of the bottom handline, 0.24 versus 0.06-hook lost per fish caught. The higher hook loss on the bottom longline was probably due to hooked fish pulling against the rigid PVC droppers, which operate standing on the bottom, compared to the bottom handline where the strain of hooked fish is absorbed by the catenary and stretch of the mainline. The problem is further aggravated with the bottom longline during multiple hook-ups, when fish pull against each other on short leaders, whereas on the handline individual fish are usually retrieved when hooked. In addition, many of the fish caught by the bottom longline are landed with hook-torn lips, and any slack on the leader often allowed fish to fall off the hook at the surface. The number of fish that were lost in this way is not known although the number was substantial.

Table 4.--Hook loss rates between deep-sea handline and Kali bottom longline fished on identical bottom fish schools at Maro Reef during Townsend Cromwell cruise 84-06.

Gear	Hook leader size (kg)	Number of hooks lost	Effort in 100-hook hours	Total fish	Total (kg)	Average fish weight (kg)	Hooks lost per fish caught	Hooks per kilogram caught
Handline	45.4	6	4.97	107	605.7	5.66	0.06	0.01
Longline	45.4	27	6.08	113	647.5	5.73	0.24	0.04

DISCUSSION

Three bottom longline designs for sampling snappers and groupers on rough bottom have been presented here. Designs A and B were unsuitable for sampling bottom fish on rough bottom. There were numerous snags on the bottom and preparing, deploying, and retrieving both longlines were time consuming and plagued with numerous tangles and safety hazards. By contrast, the Kali bottom longline was very effective at capturing bottom fish on rough bottom. Gear loss from hang-ups was limited to five droppers or <0.5% of all droppers set during the study. The gear was very easy to handle, and no problems were encountered in preparing, deploying, and retrieving the gear. There were no significant differences in CPUE between a 60-dropper set of the Kali bottom longline and bottom handline fishing with four lines, despite a high hook loss rate of 0.22-0.24 hooks/fish caught on the Kali bottom longline. Increasing the hook leader strength from 45.4 to 90.7 kg should substantially reduce hook losses and increase CPUE. Also, increasing the hook size (No. 30 or 34) would result in fish being more firmly hooked than is possible with the smaller No. 26 hooks that were used in these deployments. This would reduce the incidence of torn

lips on hooked fish and reduce the potential of fish coming free at the surface. The increase in hook size should not affect the efficiency of catching fish of the sizes targeted (Ralston 1982).

Several major shortcomings of sampling bottom fish populations with handlines are overcome by the Kali bottom longline. Fishing effort can be substantially increased with the bottom longline over that possible with deep-sea bottom handlines. Since an hour of fishing with a 60-dropper bottom longline (300 hooks) is comparable to an hour of handline fishing with four lines (16 hooks), a sampling strategy of fishing two sets of longlines so one set is fishing while the second is being retrieved will substantially increase fishing effort. Desired and actual fishing depths can be more accurately targeted and determined with the bottom longline compared to handline fishing, where winds and current drift frequently make it impossible to fish at the desired depths. Also, the variability among individual fishermen influencing catch rates during handline fishing is eliminated by bottom longline fishing.

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